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APPLICATION FOR LETTERS PATENT

**Information Management and Processing
In a Wireless Network**

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1 **TECHNICAL FIELD**

2 This invention relates to information processing and management and,
3 more particularly, to managing and processing information in a wireless network
4 system.

5
6 **BACKGROUND OF THE INVENTION**

7 The proliferation of lightweight, portable computing devices and high-
8 speed wireless local area networks (LANs) has enabled users to remain connected
9 and compute while on the move inside buildings and on campus areas around
10 buildings. This new paradigm has given birth to a new class of applications that
11 are "location aware." The goal of mobile computing in many instances is to
12 enable a user to interact effectively with his or her physical surroundings. One
13 example of such an interaction is to find a fixed network resource that is nearest to
14 a mobile computing unit so that the user of the mobile computing unit may interact
15 with the fixed network resource.

16 A key distinguishing feature of these systems is that the application
17 information and/or interface presented to the user is, in general, a function of his
18 or her physical location. The granularity of location information needed may vary
19 from one application to another. For example, locating a nearby printer requires
20 fairly coarse-grained location information whereas locating a book in a library
21 would require fine-grained information.

22 One component of these systems is the actual tracking system, which
23 determines a user's location. For example, one such system is the Global
24 Positioning System (GPS), which provides inexpensive and portable devices that
25 can locate and track users. Such systems currently are used to provide direction to

1 drivers through an in-vehicle system, provide location and tracking information
2 for marine navigation, and allow shipping companies to locate and track individual
3 shipments. However, the GPS system relies on an unobstructed view of several
4 satellites, making its use for tracking users who are indoors ineffective.

5 To overcome this obstacle, alternate technologies have been developed to
6 locate and track users or objects in an indoor environment. One such system uses
7 tags placed on the items that are to be tracked. In an electronic sense, the tags can
8 be either active or passive, and they communicate with base stations. The base
9 stations are physically linked together through a wired or wireless network. Each
10 tag transmits a unique code to identify itself. The location of the tag can thereby
11 be determined to be in the vicinity of the base station with which the tag last
12 communicated.

13 Such tag-based tracking and location systems require a significant
14 installation of specialized base stations. A tag-based system can only determine
15 the location of the tags as being "near" a particular base station. As a result, a
16 large number of base stations must be installed to achieve a sufficiently high
17 resolution. Furthermore, obtrusive tags have to be placed on every item that is to
18 be tracked or located, and in the case of infrared tags, the system operates only
19 when there is a line of sight between the tag and a base station. For these reasons,
20 tag-based systems have shown very limited success.

21 Another technology has been developed which uses radio frequency
22 transmissions from base stations and mobile units to track the location of mobile
23 units. This technology is described in U.S. Patent Application Number
24 09/_____, entitled "Using a Derived Table of Signal Strength Data to
25 Locate and Track a User In a Wireless Network, and in U.S. Patent Application

1 Number 09/_____, entitled "Locating and Tracking a User in a
2 Wireless Network Through Environmentally Profiled Data."

3 In this system, a Wireless Local Area Network (WLAN) is utilized for
4 locating and tracking users. A WLAN consists of base stations connected to a
5 wired network, and mobile devices that are "connected" to the WLAN through
6 radio frequency signals with the base stations. The signal sensing ability of both
7 the base station and the mobile device are used to determine the location of the
8 mobile device, and thus the location of the user of the mobile device. Specifically,
9 the strength of the received signal from several base stations is measured by the
10 mobile device. The mobile device then compares the signal strength from each of
11 the base stations to a pre-computed table containing the base stations' signal
12 strength at various known locations of the mobile device. From this comparison,
13 the mobile device determines its location. Alternatively, the strength of the signal
14 received from the mobile device can be measured at a number of base stations.
15 This signal strength is then compared by a central computer to a pre-computed
16 table containing the mobile computer's signal strength at the base stations for
17 various known locations. From this table, the central computer determines the
18 location of the mobile computer.

19 Such a system contains system resources that have a relatively fixed
20 location. Examples of fixed network resources include, but are not limited to,
21 access points, printers, copiers, scanners, office locations, etc. When a mobile user
22 desires to find one such fixed resource, the user submits a query to the system for
23 the location of such a fixed resource. The system determines the location of the
24 user and then searches a database on a system server that contains the location and
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1 operational properties of each fixed resource. When an appropriate fixed resource
2 is found, the information regarding the resource is returned to the user.

3 The classical way to store database records of fixed resources in a system
4 server is to store the records according to a network address and/or capabilities of
5 the fixed resource. Because such systems can be very large, there may be several
6 hundred or thousand records in a resource database that contains information on
7 every fixed resource in the system. The processing overhead required to process a
8 query for the nearest fixed resource of a certain type and having certain properties
9 can be extremely high because the search for a location as very inefficient.

10 11 **SUMMARY OF THE INVENTION**

12 Methods, systems and data structures are described in which information
13 regarding fixed resources in a wireless network system are stored as records, or
14 objects according to a location of each fixed resource.

15 A mobile user may request the location of the nearest fixed network
16 resource having certain properties. The request, or query, is transmitted to the
17 nearest base station and is forwarded to a system server. The system then
18 determines the location of the mobile user. Once the system has determined the
19 location of the mobile user, it finds the closest resource requested by the user.

20 To make the search for a fixed resource location much more efficient, the
21 fixed resources are stored as objects in a hierarchical data structure, such as a
22 directory tree, according to the location of the fixed resources. A lowest level of
23 the directory tree corresponds to a smallest geographical region in which the fixed
24 resource is located. Each subsequently higher level in the directory tree
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1 corresponds to an increasingly larger geographical region in which the fixed
2 resource is located.

3 When a mobile user submits a query to find the nearest fixed resource
4 having certain properties, the system begins the search in the directory tree
5 structure at the level in which the base station receiving the request is located. For
6 example, if a query from a mobile user searching for a printer is transmitted to a
7 base station described as USA/Washington/Redmond/Main/Bldg112/Floor2/AP3
8 (access point 3), the search begins
9 at:USA/Washington/Redmond/Main/Bldg112/Floor2. If a matching printer is not
10 found at level Floor2, the search continues up the hierarchy to level Bldg112. If a
11 match is not found in Bldg112, the search continues at level Main, and so on.

12 If the system includes more than one server, the database containing the
13 directory tree structure is replicated on each server in the system. Therefore, no
14 matter which server receives a query transmission from a mobile user, the search
15 can be performed on that server. If a change is made to the database on any server,
16 the altered database is copied to the other servers.

17 Additional features and advantages of the invention will be made apparent
18 from the following detailed description of illustrative implementations, which
19 proceeds with reference to the accompanying figures.

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BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the various methods and arrangements of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a block diagram generally illustrating an exemplary computer system on which the present invention resides.

Fig. 2 is a block diagram of a remote server in a wireless network system.

Fig. 3 is a block diagram of a hierarchical directory structure utilized in the present invention.

Fig. 4 is a flow diagram of a method for finding a fixed resource that is nearest to a mobile user.

DETAILED DESCRIPTION

The invention is illustrated in the drawings as being implemented in a suitable computing environment. Although not required, the invention will be described in the general context of computer-executable instructions, such as program modules, to be executed by a personal computer. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the invention may be practiced with other computer system configurations, including hand-held devices, multiprocessor systems, microprocessor based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. The invention may also be practice in distributed computing environments where tasks are

1 performed by remote processing devices that are linked through a communications
2 network. In a distributed computing environment, program modules may be
3 located in both local and remote memory storage devices.

4 With reference to Fig. 1, an exemplary wireless network system 10 for
5 implementing the invention includes a general purpose computing device in the
6 form of a conventional mobile personal computer 20, including a processing unit
7 21, a system memory 22, and a system bus 23 that couples various system
8 components including the system memory to the processing unit 21. The system
9 bus 23 may be any of several types of bus structures including a memory bus or
10 memory controller, a peripheral bus, and a local bus using any of a variety of bus
11 architectures. The system memory includes read only memory (ROM) 24 and
12 random access memory (RAM) 25. A basic input/output system (BIOS) 26,
13 containing the basic routines that help to transfer information between elements
14 within the mobile personal computer 20, such as during start-up, is stored in ROM
15 24. The mobile personal computer 20 further includes a hard disk drive 27 for
16 reading from and writing to a hard disk 60, a floppy disk drive 28 for reading from
17 or writing to a removable magnetic disk 29, and an optical disk drive 30 for
18 reading from or writing to a removable optical disk 31 such as a CD ROM or other
19 optical media.

20 The hard disk drive 27, floppy disk drive 28, and optical disk drive 30 are
21 connected to the system bus 23 by a hard disk drive interface 32, a floppy disk
22 drive interface 33, and an optical disk driver interface 34, respectively. The drives
23 and their associated computer-readable media provide non-volatile storage of
24 computer-readable instructions, data structures, program modules and other data
25 for the mobile personal computer 20. Although the exemplary environment

1 described herein employs a hard disk 60, a removable magnetic disk 29, and a
2 removable optical disk 31, it will be appreciated by those skilled in the art that
3 other types of computer-readable media which can store data that is accessible by
4 a computer, such as magnetic cassettes, flash memory cards, digital video disks,
5 Bernoulli cartridges, random access memories, read only memories, and the like
6 may also be used in the exemplary operating environment.

7 A number of program modules may be stored on the hard disk 60, magnetic
8 disk 29, optical disk 31, ROM 24 or RAM 25, including an operating system 25,
9 one or more application programs 36, other program modules 37, and a program
10 data 38. A user may enter commands and information into the mobile personal
11 computer 20 through input devices such as a keyboard 40 and a pointing device
12 42. Other input devices (not shown) may include a microphone, joystick, game
13 pad, satellite dish, scanner, or the like. These and other input devices are often
14 connected to the processing unit 21 through a serial port interface 46 that is
15 coupled to the system bus, but may be connected by other interfaces, such as a
16 parallel port, game port or universal serial bus (USB). A monitor 47 or other type
17 of display device is also connected to the system bus 23 via an interface, such as a
18 video adapter 48. In addition to the monitor, personal computers typically include
19 other peripheral output devices, not shown, such as speakers and printers.

20 The mobile personal computer 20 may operate in a networked environment
21 using logical connections to one or more remote computers, such as a server 49.
22 The remote server 49 may be another type of remote computer, such as another
23 personal computer, a router, a network PC, a peer device or other common
24 network node, and typically includes many or all of the elements described above
25 relative to the mobile personal computer 20, although only a memory storage

1 device 50 has been illustrated in Figure 1. The logical connections depicted in
2 Figure 1 include a Wireless Local Area Network (WLAN) 51 and a wide area
3 network (WAN) 52. Such networking environments are commonplace in offices,
4 enterprise-wide computer networks, intranets and the Internet.

5 When used in a WLAN networking environment, the mobile personal
6 computer 20 is connected to the local network 51 through a wireless network
7 interface or adapter 53. The wireless interface 53 transmits wireless packets to a
8 base station 61. The base station 61 can then retransmit the packets, either through
9 a wired or wireless network to the remote server 49. When used in a WAN
10 networking environment, the personal computer 20 typically includes a modem 54
11 or other means for establishing communications over the WAN 52. The modem
12 54, which may be internal or external, is connected to the system bus 23 via the
13 serial port interface 46. In a networked environment, program modules depicted
14 relative to the mobile personal computer 20, or portions thereof, may be stored in
15 the remote memory storage device. It will be appreciated that the network
16 connections shown are exemplary and other means of establishing a
17 communications link between the computers may be used.

18 Fig. 1 also shows several fixed network resources, such as a printer 62, a
19 scanner 64 and a copier 66. Information about the fixed resources 62, 64, 66 is
20 contained in a resource database 68 stored in the memory storage device 50.
21 Information contained included information regarding location of each fixed
22 resource and properties of each fixed resource. It is noted that, while only a few
23 fixed resources are shown, any number of fixed resources may be logically or
24 directly connected to the remote server 49. Other resources are not necessarily
25 connected to the remote server 49. Though not shown or discussed in the present

1 example, other examples of fixed resources include an office, files, documents, e-
2 mail addresses, databases, users, distributed components, and the like. It is also
3 noted that one implementation includes landmarks or points of interest as
4 resources. For example, if one wishes to map a network according to tourist
5 attractions, then the described invention(s) could be used to do so. Anything that a
6 user may be interested in from a location point of view could be defined as a
7 resource to locate in a system implemented as described herein.

8 In the description that follows, the invention will be described with
9 reference to acts and symbolic representations of operations that are performed by
10 one or more computers, unless indicated otherwise. As such, it will be understood
11 that such acts and operations, which are at times referred to as being computer-
12 executed, include the manipulation by the processing unit of the computer of
13 electrical signals representing data in a structured form. This manipulation
14 transforms the data or maintains it at locations in the memory system of the
15 computer, which reconfigures or otherwise alters the operation of the computer in
16 a manner will understood by those skilled in the art. The data structures where
17 data is maintained are physical locations of the memory that have particular
18 properties defined by the format of the data. However, while the invention is
19 described in the foregoing context, it is not meant to be limiting as those of skill in
20 the art will appreciate that various acts and operations described hereinafter may
21 also be implemented in hardware.

22 Fig. 2 depicts a remote server 200 similar to the remote server 49 shown in
23 Fig. 1, but shown in greater detail. The remote server 200 includes a processor
24 202 and non-volatile memory 204. Resident within the non-volatile memory 204
25 are an operating system 206, a query processor 207, a location subsystem 208 and

1 a database 210. The location subsystem 208 includes a locator 209 that is used to
2 determine the location of mobile users and resources.

3 It is noted that, in an alternative implementation, the locator 209 may be
4 located on a mobile computing unit (not shown). The locator 209 on such a
5 mobile computing unit would be used to determine the location of other mobile
6 users, fixed users and resources. However, for discussion purposes, the locator
7 209 will be discussed as being a part of the location subsystem 208 on the server
8 200.

9 The database 210 contains information regarding fixed resources, such as
10 the printer 62, scanner 64 and copier 66 shown in Fig. 1. The database 210 stores
11 such information in a hierarchical directory structure, such as a directory tree 212
12 depicted in Fig. 2. The directory tree 212 may also be referred to in the art as an
13 "organizational unit." Several organizational units may be linked together to form
14 an extensive network. The importance of the directory tree 212 and its function
15 will be described in greater detail below with reference to Figure 3.

16 It is noted that the directory tree 212 is a logical data structure. Therefore,
17 while reference is made to storing objects, records, files, etc. in the directory tree
18 212, it is understood that the directory tree 212 actually stores names of such
19 object, records, files, etc. together with pointers to those items.

20 Fig. 3 depicts the directory tree 212 structure of the database 210 having
21 multiple directory levels 300 and containing several fixed resource objects 302
22 (the examples given here include "access point" (AP), "printer" (PTR), "scanner"
23 (SCAN) and "copier" (COPY)). Access points can be base stations of a wireless
24 network or simply physical ports on a wired network. A fixed resource object 302
25 contains information regarding the fixed resource it represents, including the

1 location of the fixed resource and its properties. The directory tree 212 is
2 constructed in a simple and intuitive "bottom-up" method. Fixed resource objects
3 302 are stored in a lowest of the directory levels 300. The lowest level of the
4 directory levels 300 represents the smallest defined geographical region, or area,
5 in which the fixed resource is located (a "base" geographical region). Each
6 subsequently higher level of the directory tree 212 represents an increasingly
7 larger geographical region (an "extended" geographical region) that is covered by
8 the wireless network system 10.

9 Each of the directory levels 300 comprises a class of geographical area.
10 The class name of a top level 304 of the directory tree 212 is "country," which
11 identifies a geographical region identified by a country's border. Although only
12 one object is shown at this level, it is noted that any number of objects may be
13 stored that are in the class of "country." Also, it is noted that the geographical
14 region of "country" is an arbitrary selection, and the top level of the directory tree
15 212 may represent any geographical region. For example there may be a
16 "continent" class above "country".

17 The class immediately subordinate to "country" includes "state" and
18 "territory" 306. As the name implies, each object in this class represents a state or
19 territory within the country represented in the directory level immediately superior
20 to it. Beneath "state/territory" 306 is class "county" 308. In this class, each object
21 represents a county within a state or territory. Subordinate to the "county" level is
22 class "city" 310.

23 Two examples are given for the class(es) subordinate to the class of
24 "county." One geographical region that might be identified at this level is
25 "campus" 312. Beneath the class of "campus" is a class that includes "building"

1 and "area" 314. If an organization does not have multiple campuses, then these
2 levels may be combined into one class, designated herein as "campus building"
3 316. It is noted that the term "area" is used to denote spaces between buildings in
4 a typical business campus.

5 The level immediately subordinate to "building" 314 or "campus building"
6 316 is class "floor" 318. Even though a building may have only one floor, the
7 floor is still designated (e.g., "floor1") to comply with the structure of the
8 directory tree 212.

9 Each fixed resource object 302 is stored in a floor object 318. A fixed
10 resource object 302 is then referenced according to its place in the directory tree
11 212, e.g., USA/Washington/King/Redmond/Main/Bldg112/Floor1/ptr22 for a
12 printer having the name ptr22.

13 The classes of *country*, *state*, *territory*, *county*, *city*, *campus*, *building*, and
14 *floor* contain their absolute geographic location in terms of longitude, latitude and
15 altitude. Inside the *floor* object, fixed resource objects 302 are stored with relative
16 coordinates, e.g., x, y and, sometimes, z offsets from the absolute location of the
17 floor.

18 When searching for a resource, the search begins at the same level in the
19 hierarchy as the access point (base station), which receives the query from the
20 mobile computer. So, for example, when searching for a closest printer for a
21 mobile connected to an access point described as:

22 USA/Washington/King/Redmond/Main/Bldg112/Floor2/AP3,
23 the search begins at:

24 USA/Washington/King/Redmond/Main/Bldg112/Floor2.

25 This allows for quick and accurate location of nearby resources quickly.

1 It is noted that the selection of the levels in the hierarchy is arbitrary and
2 can be set to any definition desired by the user. The example given above, which
3 includes hierarchical levels that are geographic regions is but one example. A
4 different example is a hierarchy that includes levels based on landmarks or area
5 descriptions. For example, an implementation may be used that includes the
6 hierarchy of country/state/metroarea/city/area/landmark wherein the area may
7 include "downtown" and landmark may include "federal courthouse."

8 Fig. 4 is a flow chart depicting a method for locating a nearest resource in a
9 wireless network. At step 400, a mobile user sends a query requesting the location
10 of a nearest fixed resource. The query is received by the query processor 207 (step
11 402), and the locator 209 of the location subsystem 208 determines the location of
12 the mobile user and the access point to which the user is connected at step 404.

13 At step 406, the location subsystem 208 searches the database beginning at
14 the level of the access point to which the user is connected. If a match is found
15 ("Yes" branch of step 408), then location data is transmitted to the user at step 410.
16 It is noted that the query may not simply be a request for a nearest fixed resource,
17 such as a printer. The query may contain certain attributes or properties required
18 by the user, such as the nearest printer that is a color printer that the user has
19 permission to use. It is also noted that the location data may simply be the
20 location of the requested fixed resource, or it may provide specific directions for
21 the user to follow to get from the location of the user to the location of the
22 requested fixed resource.

23 If a match is not found ("No" branch of step 408), then if there is a higher
24 level in the directory tree 212 ("Yes" branch of step 412), the search will continue
25 at that level at step 416. If there is not a higher level in the directory tree 212

1 ("No" branch of step 412), then a "No Match Found" message is transmitted to the
2 user at step 414.

3 One implementation of the current invention utilizes the Active Directory™
4 service included in Microsoft® Windows® 2000. Active Directory™ is the
5 foundation of Windows® 2000 distributed networks. The Active Directory™
6 APIs (application program interfaces) provide access to the data stored in a
7 directory. Further references may be made to terms utilized in Active Directory™.
8 Detailed explanation may not be provided herein as those skilled in the art are
9 assumed to understand Active Directory™ terms.

10 Active Directory Service Interfaces (ADSI) is a set of COM (common
11 object model) interfaces used to access the capabilities of directory services from
12 different network providers in a distributed computing environment to present a
13 single set of directory service interfaces for managing network resources. ADSI
14 makes it easier to perform common administrative tasks, such as adding new
15 users, managing printers, and locating resources throughout the distributed
16 computing environment.

17 Services can be published in a directory and users can use the directory to
18 find the services. Publishing a service in Active Directory™ enables users and
19 administrators to move from a machine-centric view of the distributed system to a
20 service-centric view.

21 The present invention contemplates modifying the Active Directory™
22 schema to include the following classes and attributes.
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Structural Classes

Level 1:

Class: *locCampus*

General

Common Name: Location-Campus

X.500 OID: *to be assigned*

Class Type Structural

Relationship

Parent Class: top

Auxiliary Classes:

Possible Superior: organizationalUnit

Attributes

Mandatory:

Optional: bldgName

Level 2:

Class: *locBuilding*

General

Common Name: Location-Building

X.500 OID: *to be assigned*

Class Type Structural

Relationship

Parent Class: top

Auxiliary Classes: absoluteLocation

Possible Superior: locCampus

Attributes

Mandatory:

Optional:

Level 2 (cont'd):

Class: *locArea*

General

Common Name: Location-Area
X.500 OID: *to be assigned*
Class Type: Structural

Relationship

Parent Class: top
Auxiliary Classes: absoluteLocation
Possible Superior: locCampus

Attributes

Mandatory:
Optional: CommonName

Level 3:

Class: *locFloor*

General

Common Name: Location-Floor
X.500 OID: *to be assigned*
Class Type: Structural

Relationship

Parent Class: top
Auxiliary Classes: absoluteLocation
Possible Superior: locBuilding

Attributes

Mandatory:
Optional: posZOffset

Level 4 (Resources):

Class: *resWirelessAP*

General

Common Name: Resource-Wireless AP
X.500 OID: *to be assigned*
Class Type: Structural

Relationship

Parent Class: top
Auxiliary Classes: relativeLocation
Possible Superior: locFloor; locArea

Attributes

Mandatory: macAddress, IpAddress
Optional:

(Similar resource classes exist for printers, scanners, copiers, fax machines, or any other network-capable device that is shared by network users.)

Auxiliary Classes

Class: *absoluteLocation*

General

Common Name: Absolute-Location

X.500 OID: *to be assigned*

Class Type Auxiliary

Relationship

Parent Class: top

Auxiliary Classes:

Possible Superior:

Attributes

Mandatory: posLongitude, posLatitude,
posAltitude

Optional:

Class: *relativeLocation*

General

Common Name: Relative-Location

X.500 OID: *to be assigned*

Class Type Auxiliary

Relationship

Parent Class: top

Auxiliary Classes:

Possible Superior:

Attributes

Mandatory: posXOffset, posYOffset

Optional: posZOffset

In a simple implementation, a printer may be represented as an object of type *PrintQueue* and is placed in the directory server tree as a child object of the machine that is servicing the printer. For example, if in domain **redmond..microsoft.com**, machine **mcom3** is hosting printer **laserjet**, the complete path for the printer would be:

LDAP://DC=com/DC=microsoft/DC=redmond/CN=computers/CN=mcom3/CN=mcom3-laserjet

A more difficult, but more proper, mechanism for representing a printer within the location hierarchy is to create a *PrintQueue* object in the location

1 hierarchy that shadows or references the object at its normal location within the
2 directory server hierarchy.

3 **Conclusion**

4 The described implementations advantageously provide for an efficient way
5 in which to store and search for location information of fixed resources in a
6 wireless network. Other advantages will be apparent to those of skill in the art.

7 Although the invention has been described in language specific to structural
8 features and/or methodological steps, it is to be understood that the invention
9 defined in the appended claims is not necessarily limited to the specific features or
10 steps described. Rather, the specific features and steps are disclosed as preferred
11 forms of implementing the claimed invention.